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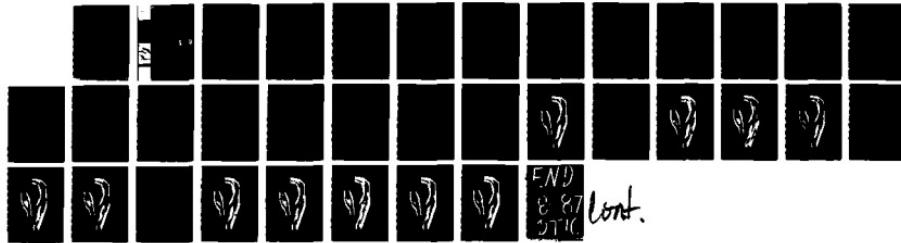
BANK PROTECTION BASS LOCATION WILLAMETTE RIVER OREGON
HYDRAULIC MODEL INV (U) ARMY ENGINEER WATERWAYS
EXPERIMENT STATION VICKSBURG MS HYDRA
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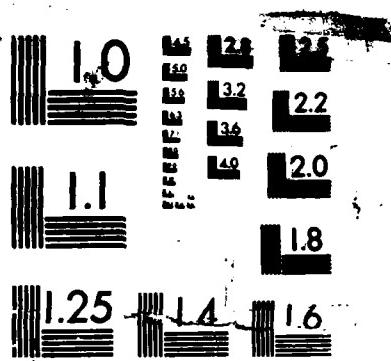
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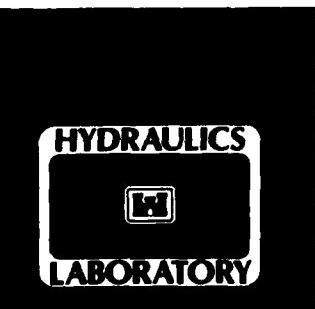
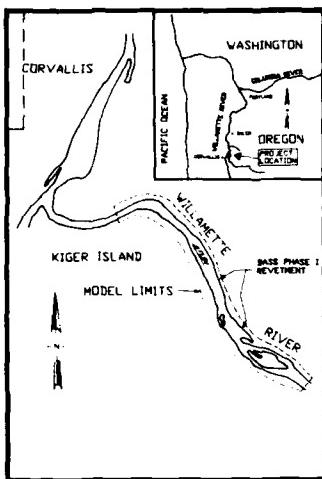
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MICROCOPY RESOLUTION TEST CHART



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TECHNICAL REPORT HL-87-7

BANK PROTECTION, BASS LOCATION WILLAMETTE RIVER, OREGON

Hydraulic Model Investigation

by

Randy A. McCollum, C. Wayne O'Neal, J. Edwin Glover

Hydraulics Laboratory

DEPARTMENT OF THE ARMY
Waterways Experiment Station, Corps of Engineers
PO Box 631, Vicksburg, Mississippi 39180-0631

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May 1987
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19. ABSTRACT (Continued).

b. Installation of the groins plus closing of the right channel at river mile 136.7.

Results of the study indicate that:

- a. Installation of the eight groins below the Bass Phase I revetment will greatly reduce the erosion of the bank line and cause no significant increase of velocities in the channel.
- b. Installation of the groins plus closing of the right channel at river mile 136.7 will reduce the erosion of the right bank, but not to the extent that groins without the right channel closure would. Velocities on the bank opposite the groins increased enough to cause concern for erosion of the left bank.

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PREFACE

The hydraulic model investigation reported herein was conducted for the US Army Engineer District, Portland (NPP), in the Hydraulics Laboratory of the US Army Engineer Waterways Experiment Station (WES), Vicksburg, Mississippi.

The investigation was conducted during the period September 1982 to February 1983 under the general supervision of Messrs. H. B. Simmons and F. A. Herrmann, Jr., former and present Chiefs of the Hydraulics Laboratory; and under the direct supervision of Messrs. J. E. Glover, Chief of the Waterways Division, and C. W. O'Neal, Chief of the River Regulation Branch. The engineer in immediate charge of the model was Mr. R. A. McCollum, assisted by Mrs. D. C. Derrick, both of the River Regulation Branch. This report was prepared by Messrs. Glover, O'Neal, and McCollum assisted by Mrs. Derrick. This report was edited by Mrs. Beth F. Burris, Information Products Division, Information Technology Laboratory.

Representatives of NPP who were actively involved in the study were Messrs. Floyd Hall, Roy Wellington, and William Csajko. Also involved in the study was Mr. John Oliver of the US Army Engineer Division, North Pacific.

COL Allen F. Grum, USA, was the previous Director of WES. COL Dwayne G. Lee, CE, is the present Commander and Director. Technical Director is Dr. Robert W. Whalin.

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**CONVERSION FACTORS, NON-SI TO SI (METRIC)
UNITS OF MEASUREMENT**

Non-SI units of measurement used in this report can be converted to SI (metric) units as follows:

<u>Multiply</u>	<u>By</u>	<u>To Obtain</u>
cubic feet per second	0.02831685	cubic metres per second
feet	0.3048	metres
inches	25.4	millimetres
miles (US statute)	1.609347	kilometres

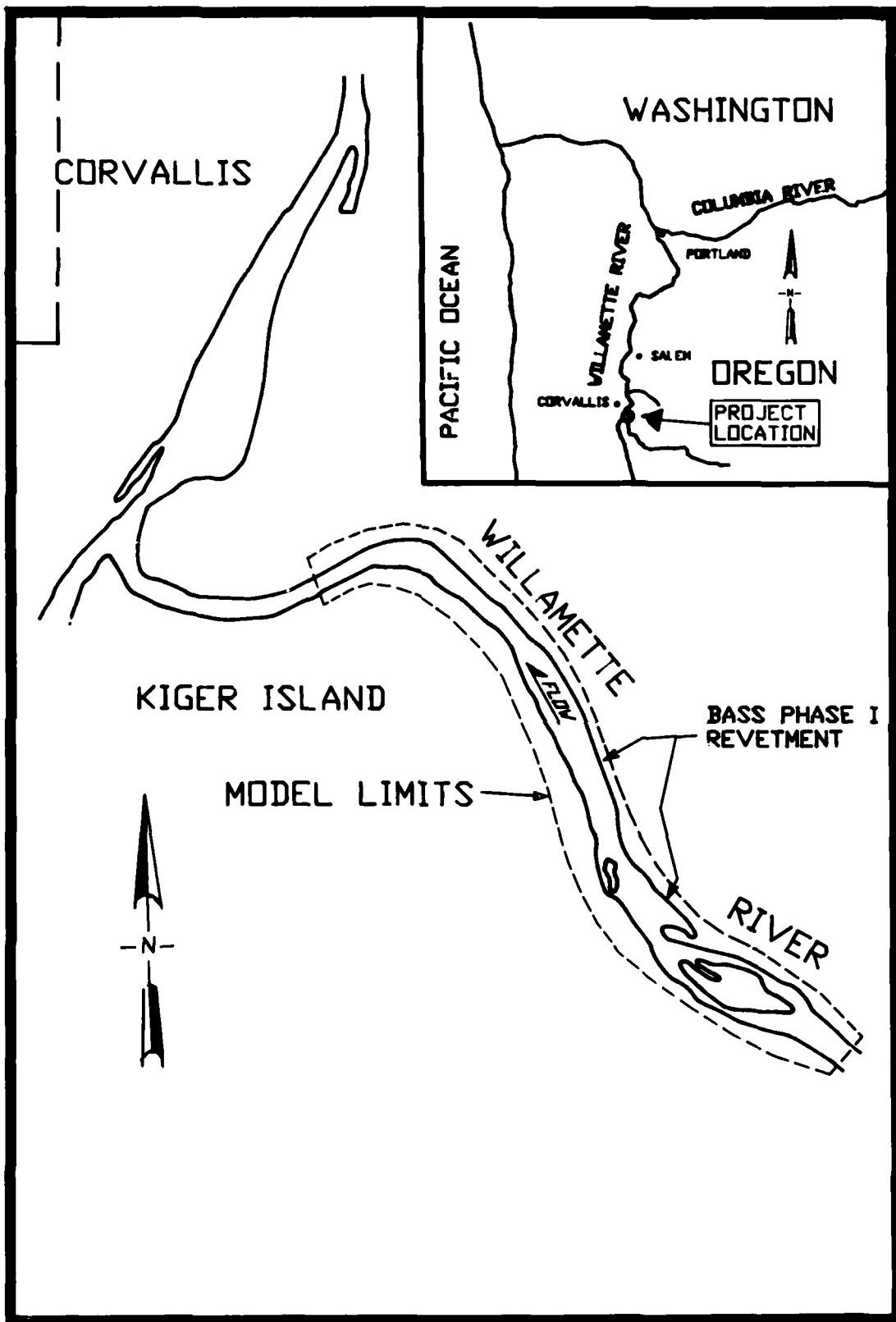


Figure 1. Location map

BANK PROTECTION, BASS LOCATION, WILLAMETTE RIVER, OREGON

Hydraulic Model Investigation

PART I: INTRODUCTION

Location and Description of Prototype

1. The Willamette River flows northerly through west-central Oregon, emptying into the Columbia River just northwest of Portland, Oregon. The reach of concern for this model study, located just southeast of Corvallis, Oregon, is known as the Bass Location, running from river miles 137 to 135 (Figure 1).

2. The riverbed in the area of interest is mostly gravel and cobbles, 50 percent or more being one-half inch* or larger in diameter. The bank line is a mixture of finer gravel and sand. This makes the bank line much more susceptible to erosion than the bed. To protect eroding banks, riprap revetment has been laid on the banks in many areas as bank erosion warrants.

3. Environmentalists have questioned the use of revetment for all bank protection problems. Consideration is being given to the use of stone groins to protect the banks. Environmental studies have indicated that stone groins provide a favorable habitat for river organisms and fish.

Need for and Purpose of Model Study

4. The Bass Phase I revetment was placed in 1981 after severe erosion during the years 1977 to 1980 (Figure 1). The area below the Bass Phase I revetment is also experiencing heavy erosion of the right bank. Normally, this area would be revetted as was the Bass Phase I area. Due to the concerns of the various environmental groups, a proposal to use stone groins as an alternative is to be considered.

5. Since any channel training works are site-specific and many factors not amenable to analytic analysis are involved in developing the structures

* A table of factors for converting non-SI units of measurement to SI (metric) units is presented on page 3.

necessary to provide the desired result, it was decided that a physical movable-bed model study was the most appropriate method of studying the problem. The objective of the investigation was to develop a groin system capable of protecting the right bank below the Base Phase I revetment from excessive erosion and to determine if velocities in the channel would increase enough to possibly cause erosion of the left bank.

PART II: THE MODEL

Description

6. The Willamette River model was of the movable-bed type built to a horizontal scale of 1:100 and a vertical scale of 1:50. The model reproduced the prototype area between river miles 135 and 137 (Plate 1). Portions of the right overbank and all of the left overbank were molded in concrete. The difference in the bed and bank material was simulated by using different grain-size material in the channel and the erodible section of bank line. The right bank in the area of concern was molded in crushed coal having a median grain diameter of 4 mm, and the bed of the model was molded in crushed coal having a median grain diameter of about 10 mm (Figure 2). The specific gravity of the coal was 1.30. Stone groins and revetment were reproduced with crushed stone.

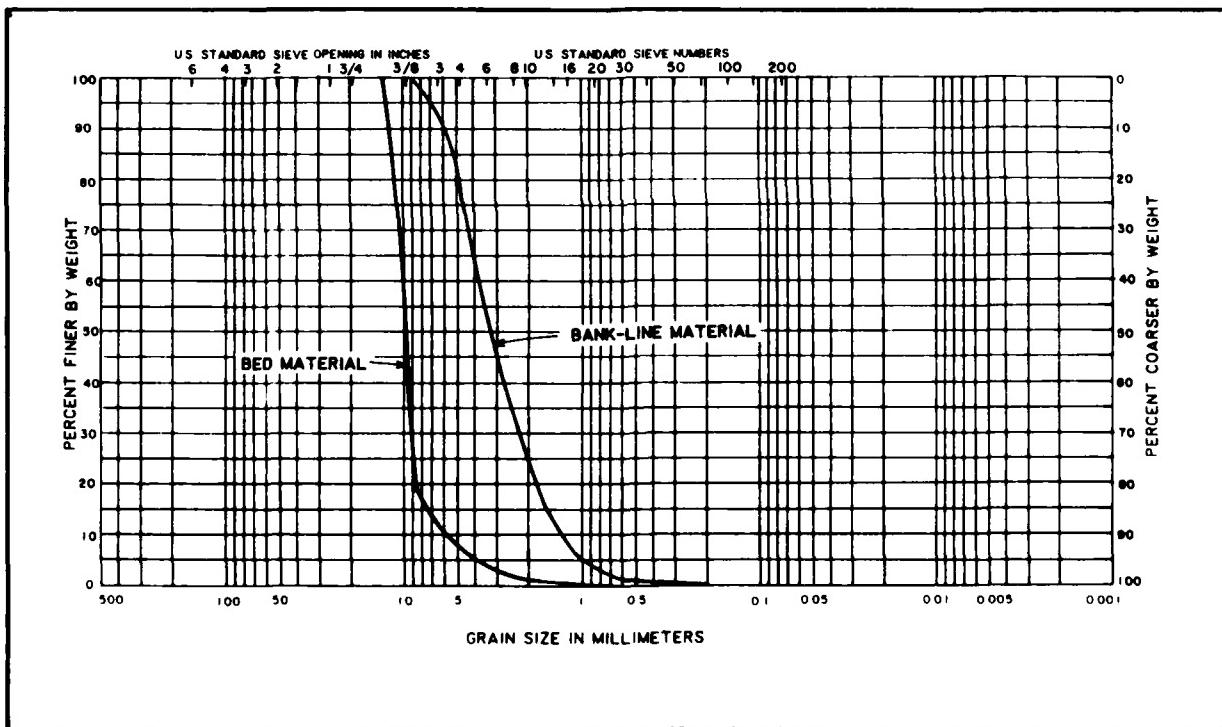


Figure 2. Final coal gradation

Appurtenances

7. Water was supplied to the model by a circulating system and was measured by use of an 8- by 4-in. venturi meter. Water-surface elevations were measured with six piezometer gages located throughout the model. Tailwater elevations were controlled with an adjustable tailgate at the downstream end of the model. Carefully graded rails running along both sides of the model provided support and a datum for templates used to mold the channel and for surveys. Bed soundings in the model were obtained by means of a traverse sounding rail supported by longitudinal rails from which a sounding rod measured the elevation of the bed at selected cross sections to the nearest prototype foot. Sheet-metal templates hung from a transverse rail were used for molding the movable bed and bank-line areas.

Model Adjustment and Verification

8. Before tests of the bank stabilization works were undertaken, the model was adjusted until it reproduced to a reasonable degree of accuracy the bank erosion shown on the available prototype surveys. Model adjustment was accomplished by operating the model with the bed molded to the 1980 prototype survey and the right bank from river miles 136.4 to 135.85 molded to the 1977 prototype survey (Plate 2). The high-water months of the hydrograph recorded between the prototype survey dates of 1977 and 1980 (Plate 3) were used because the US Army Engineer District, Portland (NPP), determined them to be the times during which the bank line erodes. The 1980 prototype survey (Plate 4) was compared with the model survey (Plate 5) taken after completion of the reproduction of the hydrograph to determine if the model reproduced the bank-line erosion of the right bank between river miles 136.4 and 135.85 as experienced in the prototype between the years 1977 and 1980. The adjustment test was repeated, modifying model-prototype discharge ratio and gradation of bank-line material until a reasonable degree of agreement between model and prototype configurations was achieved. The final gradation of the bank line and bed material used is shown in Figure 2.

Results

9. Results of the verification test (Plate 5) when compared with the prototype survey of 1980 (Plate 4) indicate that the bank erosion rates in the model were slightly greater than those recorded in the prototype. Therefore, the bank erosions during the plans tested should tend to be greater than what would be expected in the prototype. Since the model tended to have slightly greater bank erosion rates, making the results conservative in favor of the prototype, the bank-line adjustment was considered satisfactory.

10. Evaluation of all model tests considered the differences of the verification test as compared with the prototype and rated the effectiveness of each plan with respect to these differences. Since only one complete bed survey was available, the normal model bed verification was not possible. Model bed verification consisted only of ensuring that the bed configuration appeared reasonable based on experience with other model studies. Therefore, changes in bed configurations resulting from the different plans should be considered only as indications.

PART III: TESTS AND RESULTS

Test Procedure

11. Before operation of the 2-year-frequency high-water months hydrograph for the Base Test, Plan A, and Plan A-1, the model was molded with the bank lines and bed in the configuration of the 1980 prototype survey, except in the area of the Bass Phase I revetment, which was molded to the 1981 prototype survey. Tests using the 25-year-frequency high-water months hydrograph started with the ending bed configuration from the corresponding preceding test. All tests were made by beginning with reproduction of the 1977-1980 high-water months hydrograph (Plate 3). The peak discharge (50,000 cfs) during this hydrograph is the same as that of the 2-year-frequency flood. The model was then operated using a simulated 25-year-frequency high-water months hydrograph (Plate 6). This hydrograph was simulated by replacing the peak discharge flow of the 1977-1980 high-water months hydrograph (50,000 cfs) with the discharge flow that is considered by NPP to be the 25-year-frequency flood (80,000-cfs peak discharge). The hydrographs were reproduced by introducing a discharge based on the discharge ratio scale developed during the adjustment tests and maintaining the tailwater elevations at the lower end of the model.

12. The bank line downstream of the Bass Phase I revetment was carefully measured and marked preceding and following each test to note the amount of bank-line erosion (Table 1). These measurements were taken at seven ranges from the end of the Bass Phase I revetment at river mile 135.9 to the end of the proposed Phase II area, river mile 135.60. These locations marked the beginning bank line before the start of testing, then marked the bank line immediately following each test to note loss of bank line during each test. The erosion measurement ranges were spaced from 200 to 300 ft apart. Velocities were taken at several locations during all tests to note changes that occurred as a result of the installed groin plans. Velocities were made with distorted discharge and geometric scales; therefore, they should be used for comparative purposes only. The channel bed was also surveyed following each test to note any bed changes that occurred during the tests.

Base Test

Description

13. The Base Test was conducted using existing prototype conditions to determine the amount of bank erosion that would be experienced below the Bass Phase I revetment following the reproduction of the 2- and the 25-year-frequency high-water months hydrographs that were selected for model testing. The Bass Phase I revetment was installed according to construction drawings dated 24 April 1981 (Plate 7). The test using the 25-year-frequency flood hydrograph started with the model bed configuration obtained at the end of the 2-year-frequency high-water months hydrograph.

Results

14. Results of the surveys taken after the 2- and 25-year-frequency high-water months hydrographs (Plates 8 and 9) indicate a slight shoaling in the low areas of the channel, otherwise very little bed change. The amount of erosion of the unprotected bank line following each hydrograph when compared with the 1980 prototype survey indicates that the bank below the Bass Phase I revetment will erode at a fairly rapid rate. The total loss of bank line following the consecutive operation of the 2- and 25-year-frequency high-water months hydrographs ranged from 60 to 95 ft except for the bank line just downstream of the end of the Bass Phase I revetment which eroded only 35 ft (Table 1). Velocities were measured during the peak flows of both the 2- and 25-year-frequency high-water months hydrographs (Plate 10). These velocities are used as a comparison for velocities taken during plan tests.

Plan A

Description

15. Plan A (Plate 11) was developed jointly through a series of preliminary tests by representatives of NPP and the US Army Engineer Waterways Experiment Station. The plan consisted of a system of eight groins placed along the right bank from river miles 135.95 to 135.59 to protect the right bank below the Bass Phase I revetment from excessive erosion. The bank line was carefully measured to note bank erosion, and velocities (Plate 10) were taken during the peak discharge flows of the 2- and 25-year-frequency

high-water months hydrographs. The crest elevation and lengths of groins are listed in Table 2.

Results

16. The model surveys (Plates 12 and 13) indicate that the channel will deepen along the groins and shoaling will occur just downstream of the groins. The bank erosion rate was reduced from the maximum of 95 ft during the base test to 45 ft at the completion of Plan A. At bank measurement ranges D and F, erosion was stopped completely. All measurement sites showed less erosion than that during the base test. The velocities taken indicate that the water velocity will increase slightly along the Bass Phase I revetment and will be about the same or slightly less in the area opposite and below the groin system.

Plan A-1

Description

17. Plan A-1 (Plate 11) used the same groin plan as that of Plan A. The only modification was to close the right channel at river mile 136.7 with a closure structure with a crest elevation of 220 ft NGVD.* This was done to help eliminate the erosion of the right bank being experienced in the prototype from river mile 136.7 to 136.6.

Results

18. The surveys (Plates 14 and 15) taken after the 2- and 25-year-frequency high-water months hydrographs indicated channel deepening along the groins, and a shoal area formed just downstream of the groin field. The bank erosion below the Bass Phase I revetment was about the same or slightly greater than that with Plan A except at erosion measurement range C for the 25-year-frequency hydrograph where the amount of bank loss was about 20 ft less than with Plan A. Velocities tended to be about the same to 10 percent greater than those taken during the Base Test. The velocities below the groin system were slightly less. The only area of concern was the velocity range at river mile 135.8 where velocities along the left bank and out into midchannel were from 15 to 30 percent higher than those taken during the Base Test. This

* All elevations (el) and stages cited herein are in feet referred to the National Geodetic Vertical Datum (NGVD).

is due to the installed groin system and the blockage of the right channel at the island, reducing the cross-sectional area and concentrating flow along the left bank.

PART IV: SUMMARY OF RESULTS AND CONCLUSIONS

Model Limitations

19. An analysis and evaluation of the results of this investigation should consider the limitations of the model, based on the model verification, the Base Test, the hydrographs used, and the prototype survey information available. Since the prototype bed and bank material differ, the grain size for the bed material used in the model was different than that used in the bank line--coal with a median grain size of 10 mm for the bed and coal with a median grain size of 4 mm for the bank. The verification considered mostly the bank erosion that occurred in the Bass Phase I revetment region since this was the only area where more than one prototype survey was available. The bank erosion that was experienced from 1977 to 1980 was used as the basis for model adjustment. Since only total bank erosion was known, the rate of erosion for each particular flood or low-water period or in areas for which prototype information was not available may not have been duplicated exactly.

Results and Conclusions

20. The following general results and conclusions were indicated by the model investigation:

- a. The groin system of Plan A limits bank erosion to a range of 0 to 45 ft, less than half the erosion experienced between 1977 and 1980 below the Bass Phase I revetment.
- b. A slight increase in shoaling on the right side of the channel below the groins was experienced during Plan A.
- c. With Plan A, velocities in the reach increased slightly opposite the Bass Phase I revetment, an area in which both banks are protected.
- d. Closing the right channel at river mile 136.7 in addition to groins (Plan A-1) was slightly less effective in controlling bank erosion than groins alone (Plan A).
- e. Velocities along the left bank at river mile 135.8 increased from 15 to 30 percent as compared with the Base Test during Plan A-1.

Table 1
Bank Loss

Location	After 2-Year-Frequency High-Water Months Hydrograph			After 25-Year-Frequency High-Water Months Hydrograph		
	Base Test	Plan A	Plan A-1	Base Test	Plan A	Plan A-1
A	30	18	20	35	30	25
A	49	*	*	60	*	*
B	60	8	10	88	20	25
C	44	22	20	95	45	25
D	20	0	0	75	0	0
D	25	*	*	80	*	*
E	30	0	15	65	5	15
F	50	0	0	70	0	10
G	46	20	20	70	25	35
G	35	*	*	60	*	*

Note: All measurements given in prototype feet. Measurement locations shown in Plates 7 and 11.

* Location of groins for Plans A and A-1.

Table 2
Crest Elevations and Length of Groins

Groin No.	River Mile	Groin Type	Length, Prototype ft		Crest Elevation ft NGVD	
			Spur	L	Root	End
1	135.95	Spur	80		216	215
2	135.91	Spur	80		220	220
3	135.86	Spur	80		220	220
4	135.81	Spur	85		220	220
5	135.76	L-head	80	65	220	220
6	135.71	L-head	80	50	220	220
7	135.66	L-head	75	70	220	220
8	135.59	L-head	90	60	220	220

MODEL LAYOUT

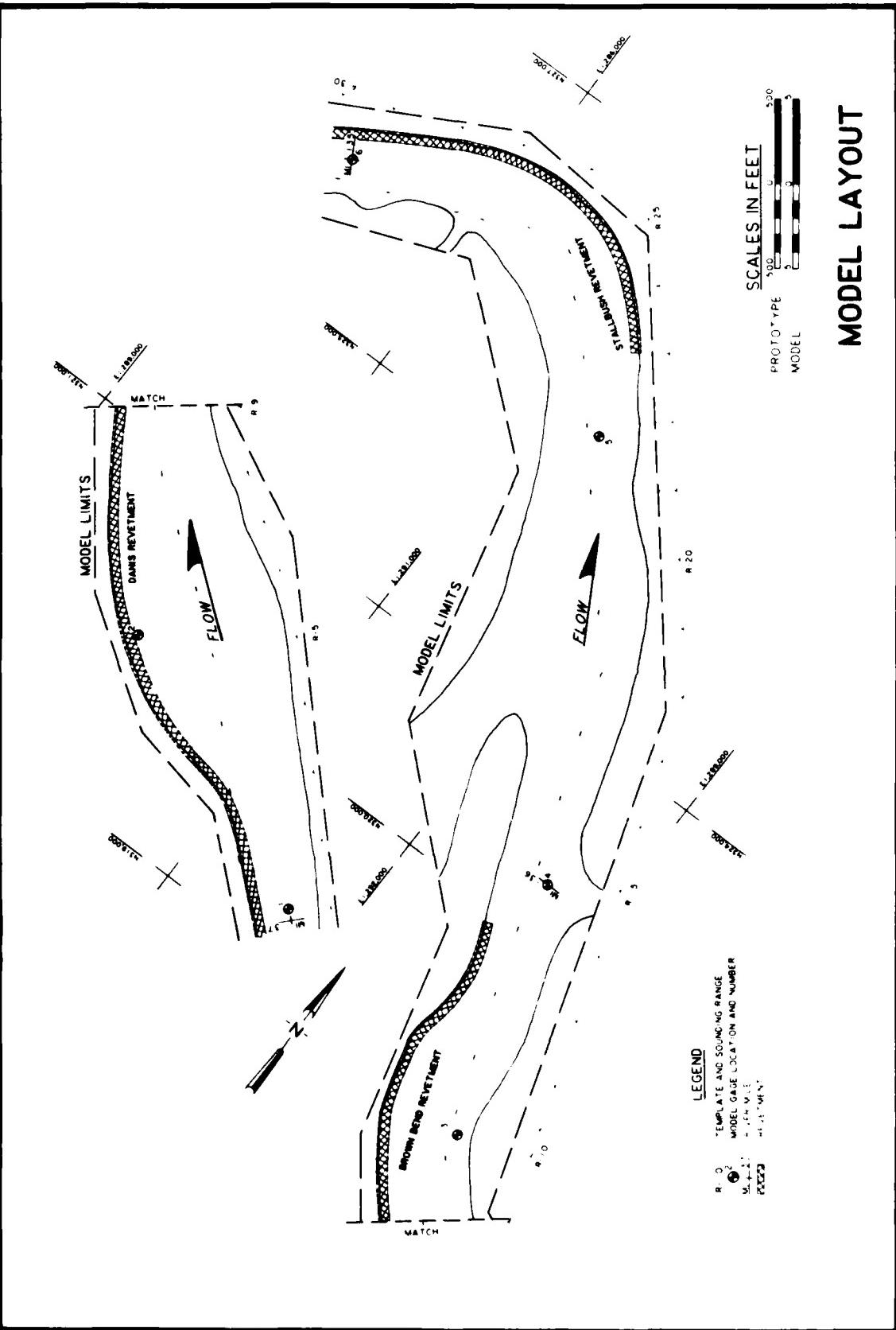


PLATE 1

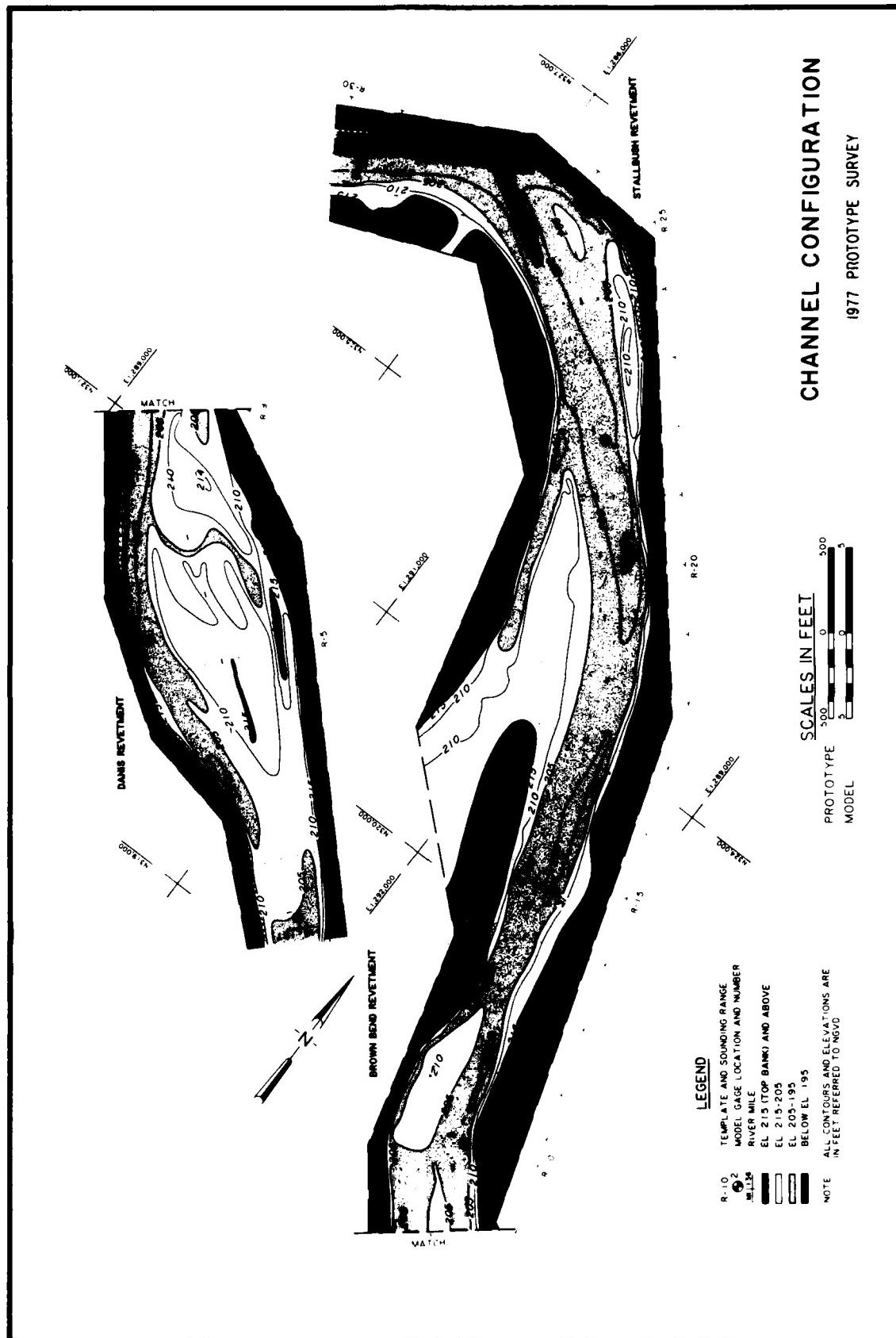
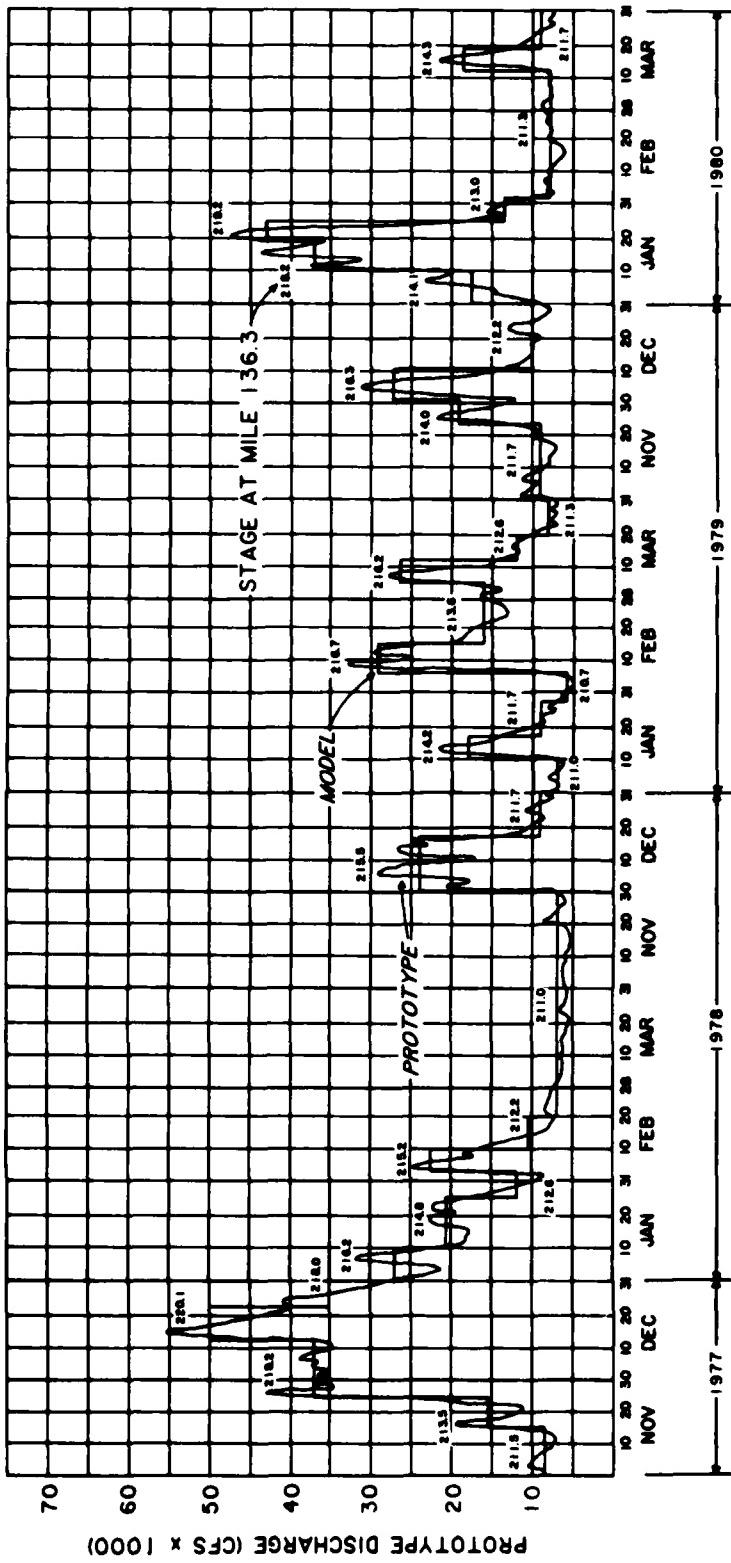
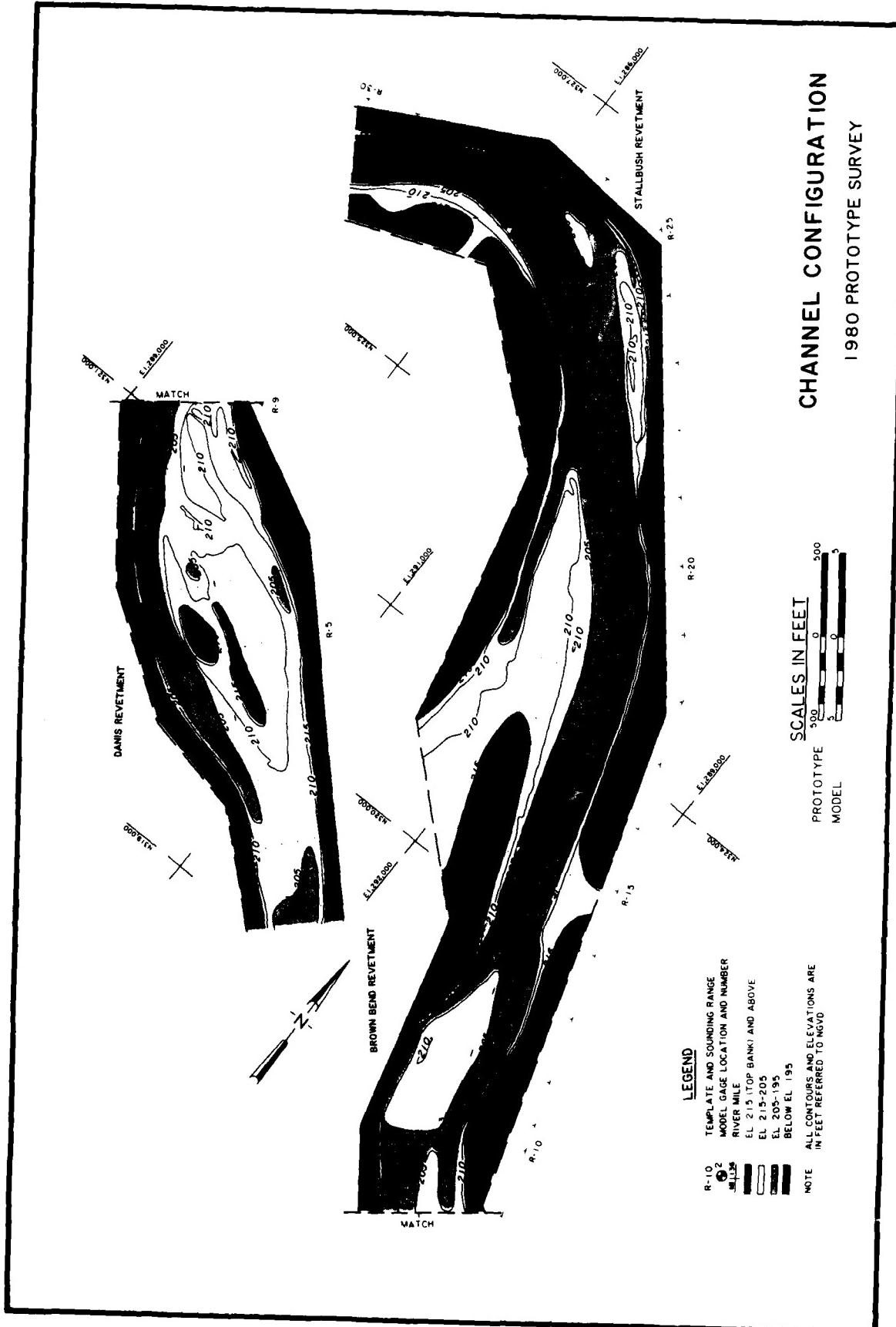


PLATE 2



MODEL ADJUSTMENT AND 2-YEAR-FREQUENCY HIGH-WATER MONTHS HYDROGRAPH

NOTE: NUMBERS INDICATE STAGE ELEVATION IN FEET NGVD



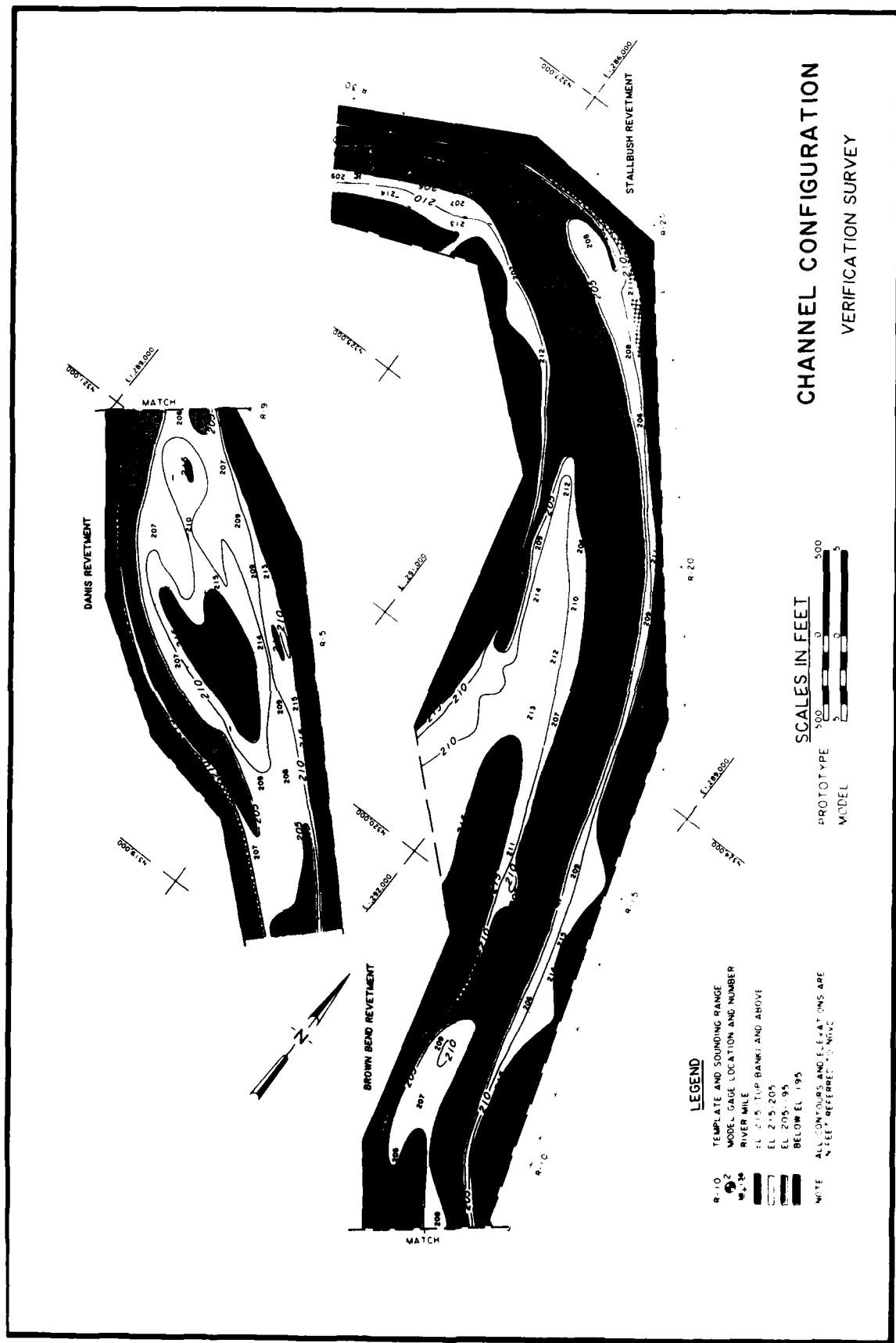


PLATE 5

CHANNEL CONFIGURATION
BASE TEST
BEGINNING CONDITIONS

SCALES IN FEET

PROTOTYPE	500
MODEL	500

LEGEND

- R 1007 TEMPLATE AND SOUNDING RANGE
UNDER GAGE LOCATION AND NUMBER
- RIVER MILE
- STONE REVETMENT
- BANK EROSION MEASUREMENT SITE
- EL 215.203 HAMP 215.203
EL 205.195
- BELLOW EL 195
- NOTE ALL CONTOURS AND ELEVATIONS ARE
IN FEET REFERRED TO NOAO

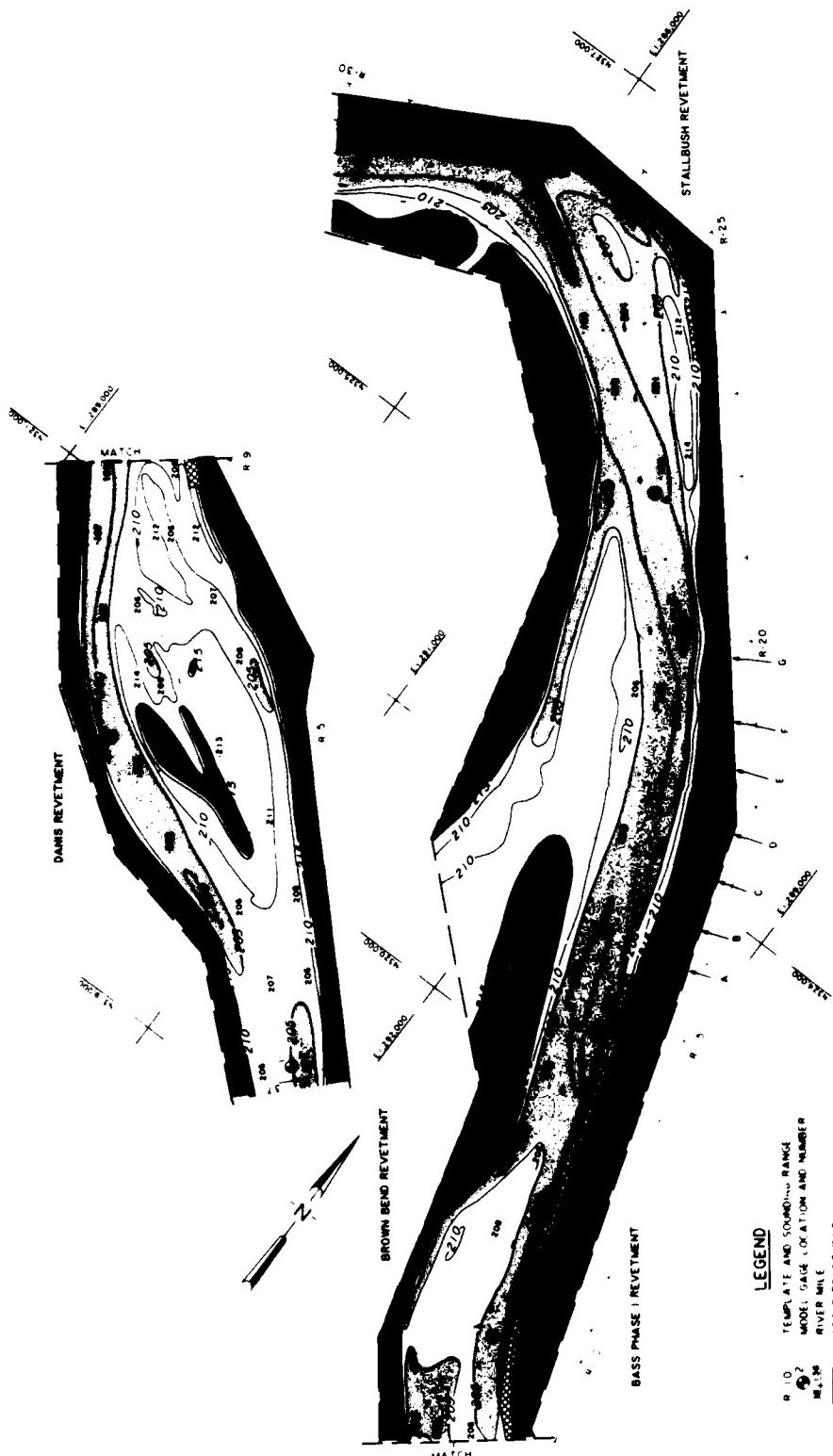


PLATE 6

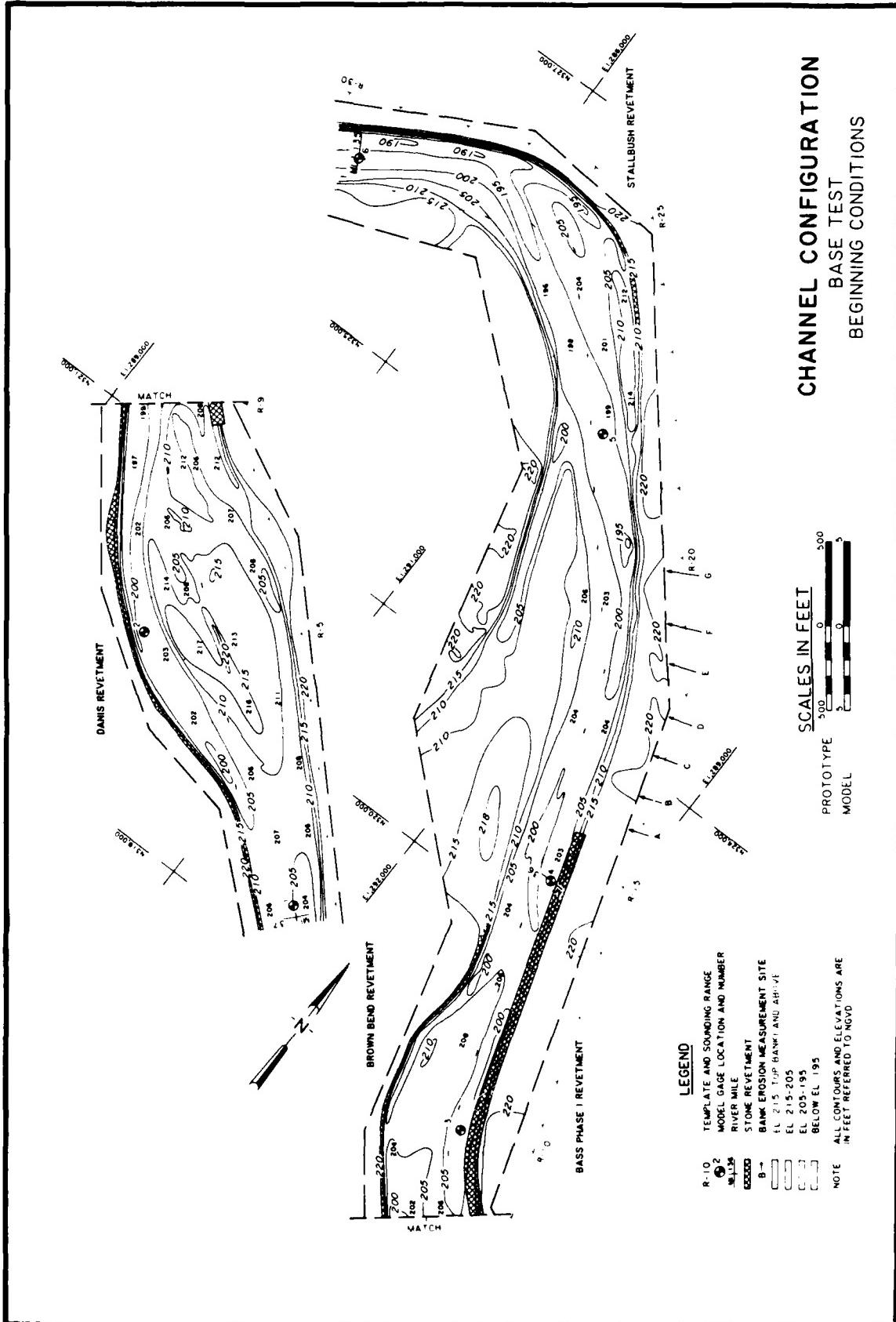


PLATE 7

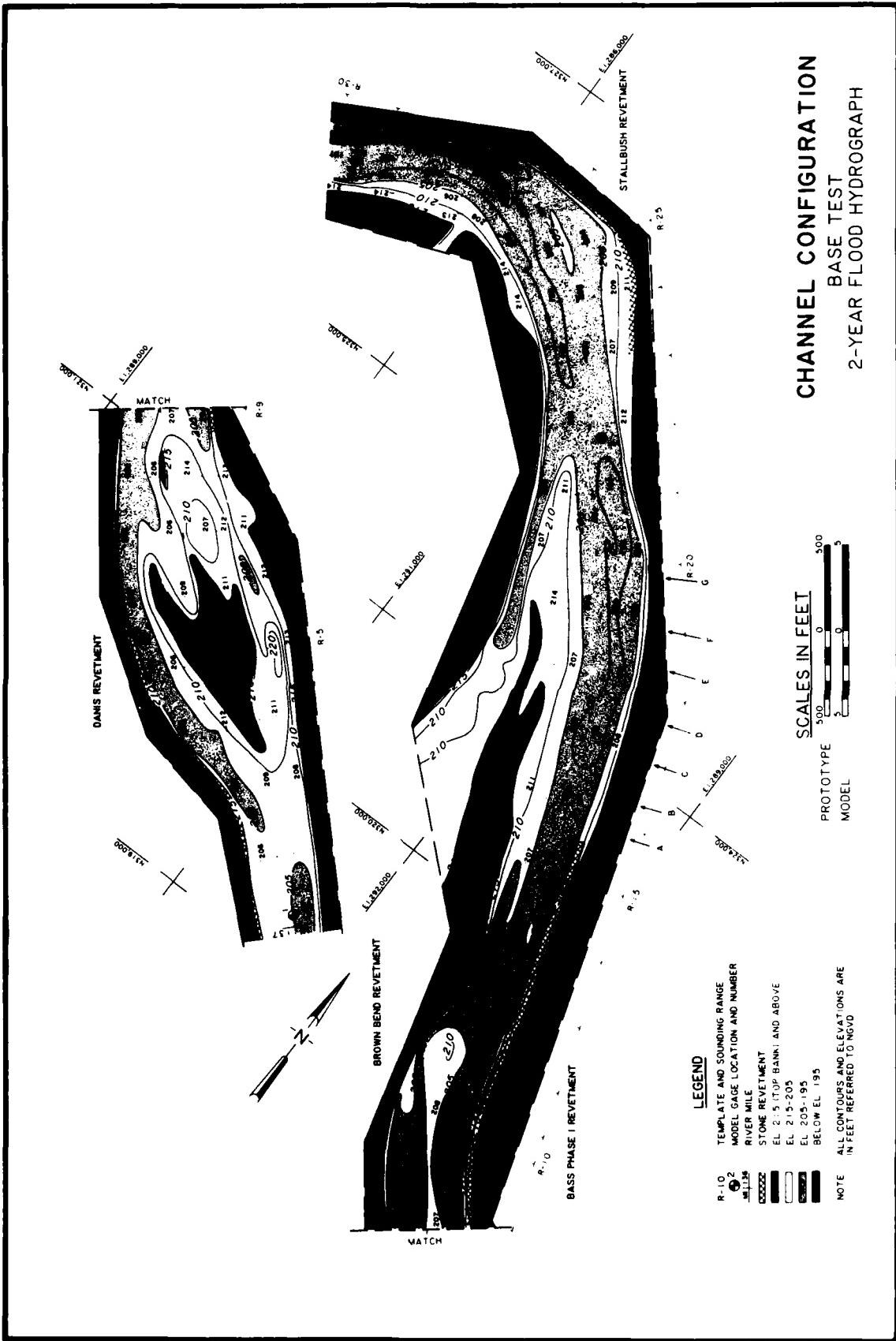


PLATE 8

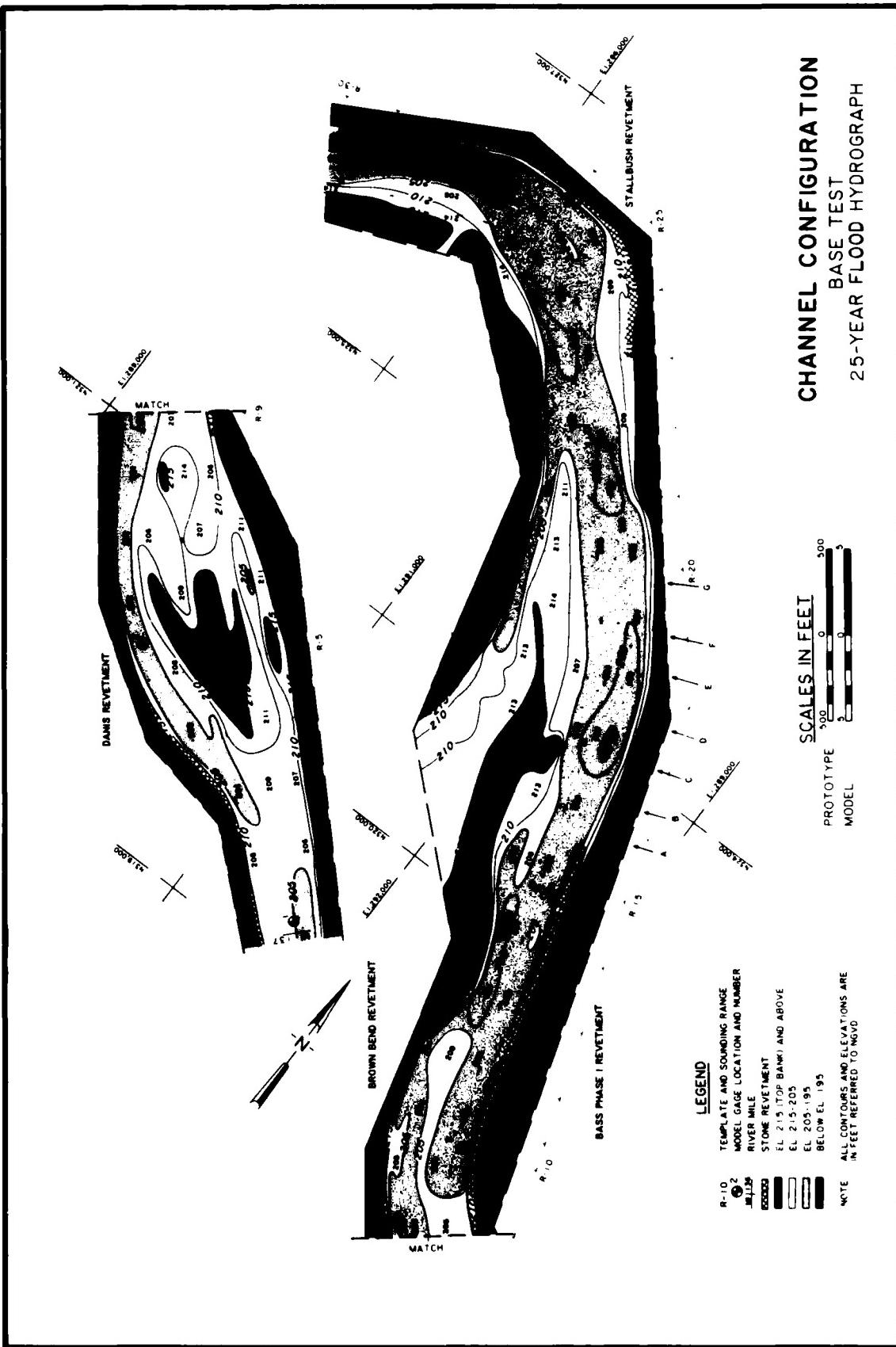


PLATE 9

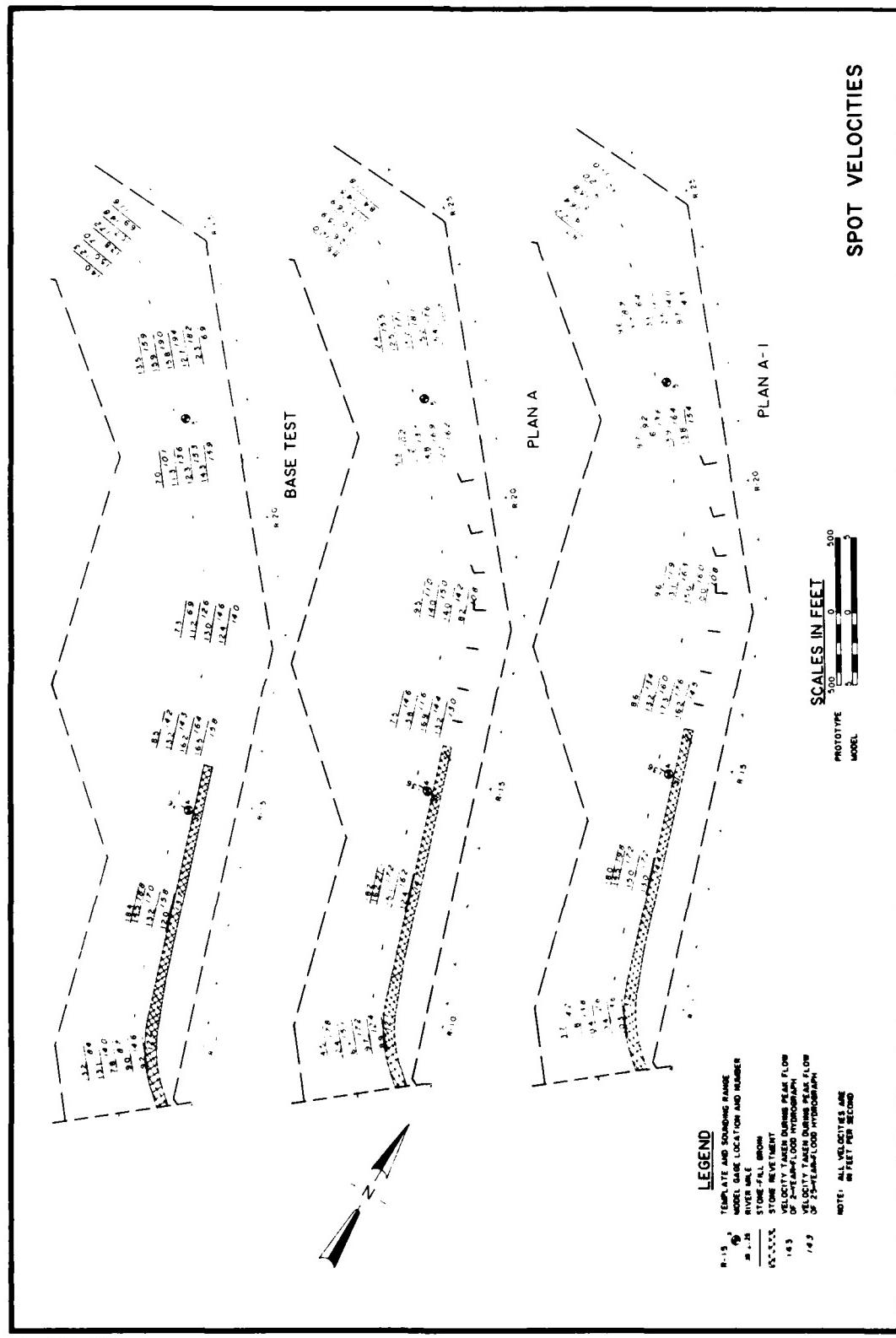
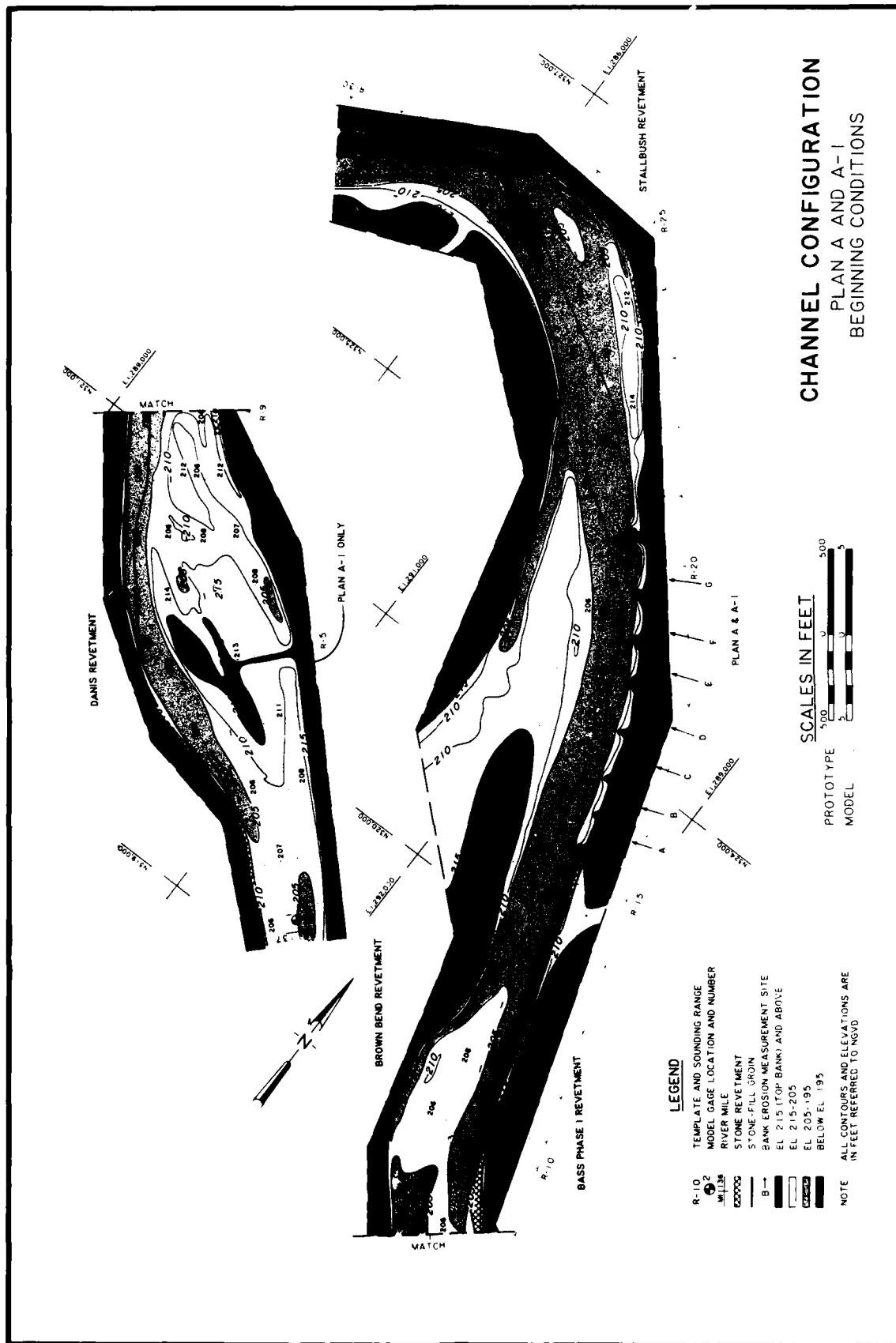
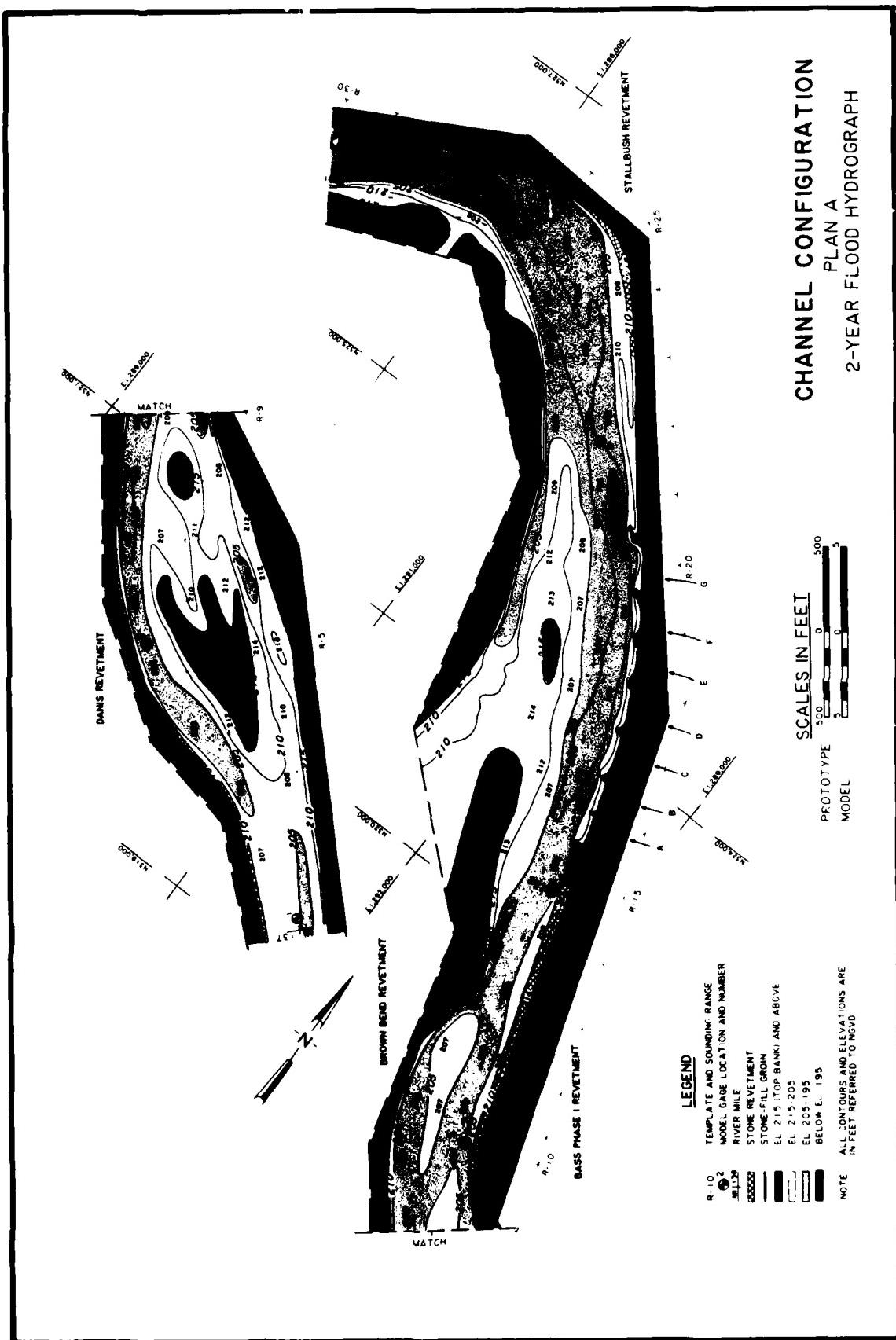


PLATE 10





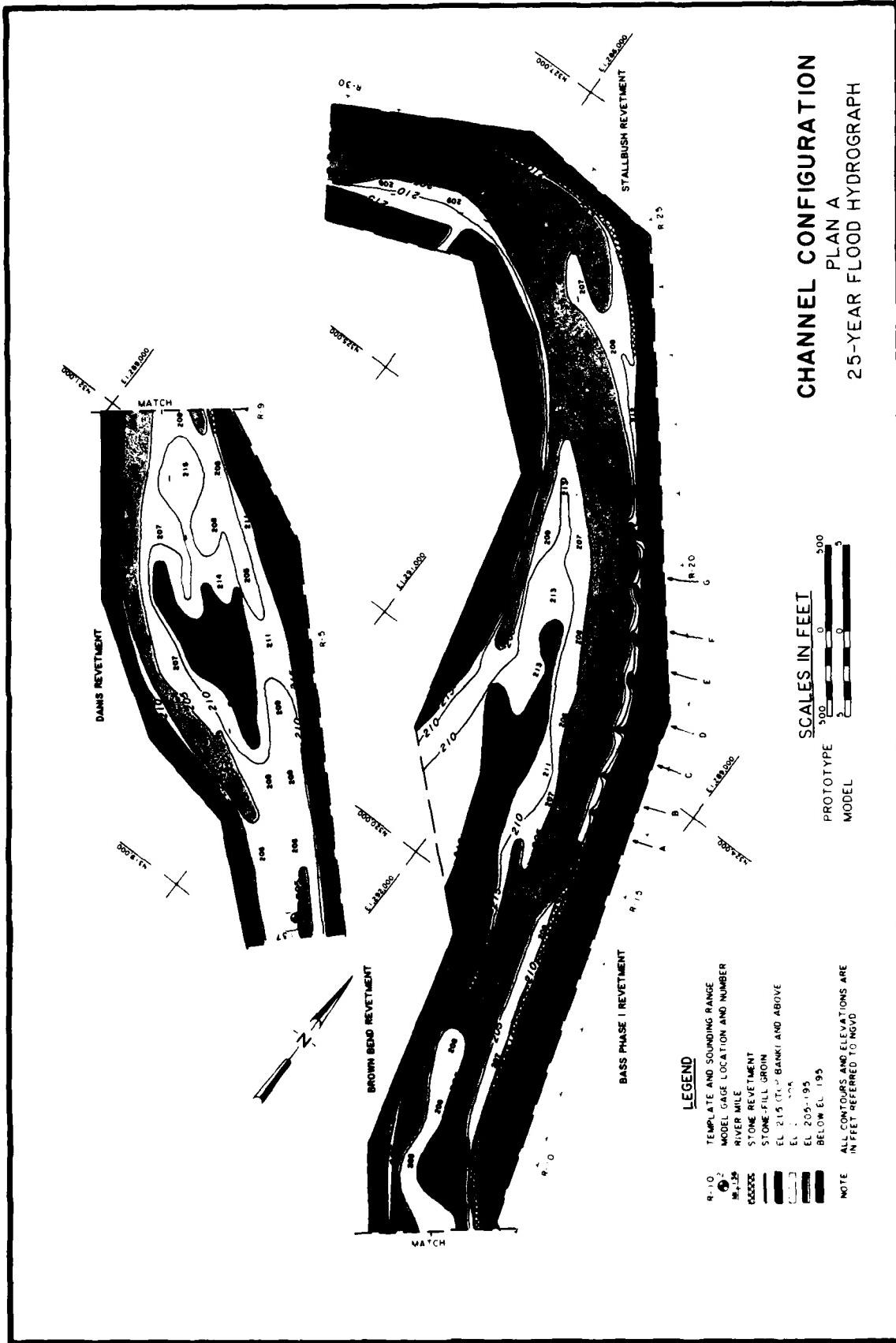


PLATE 13

CHANNEL CONFIGURATION
PLAN A-1
2-YEAR FLOOD HYDROGRAPH

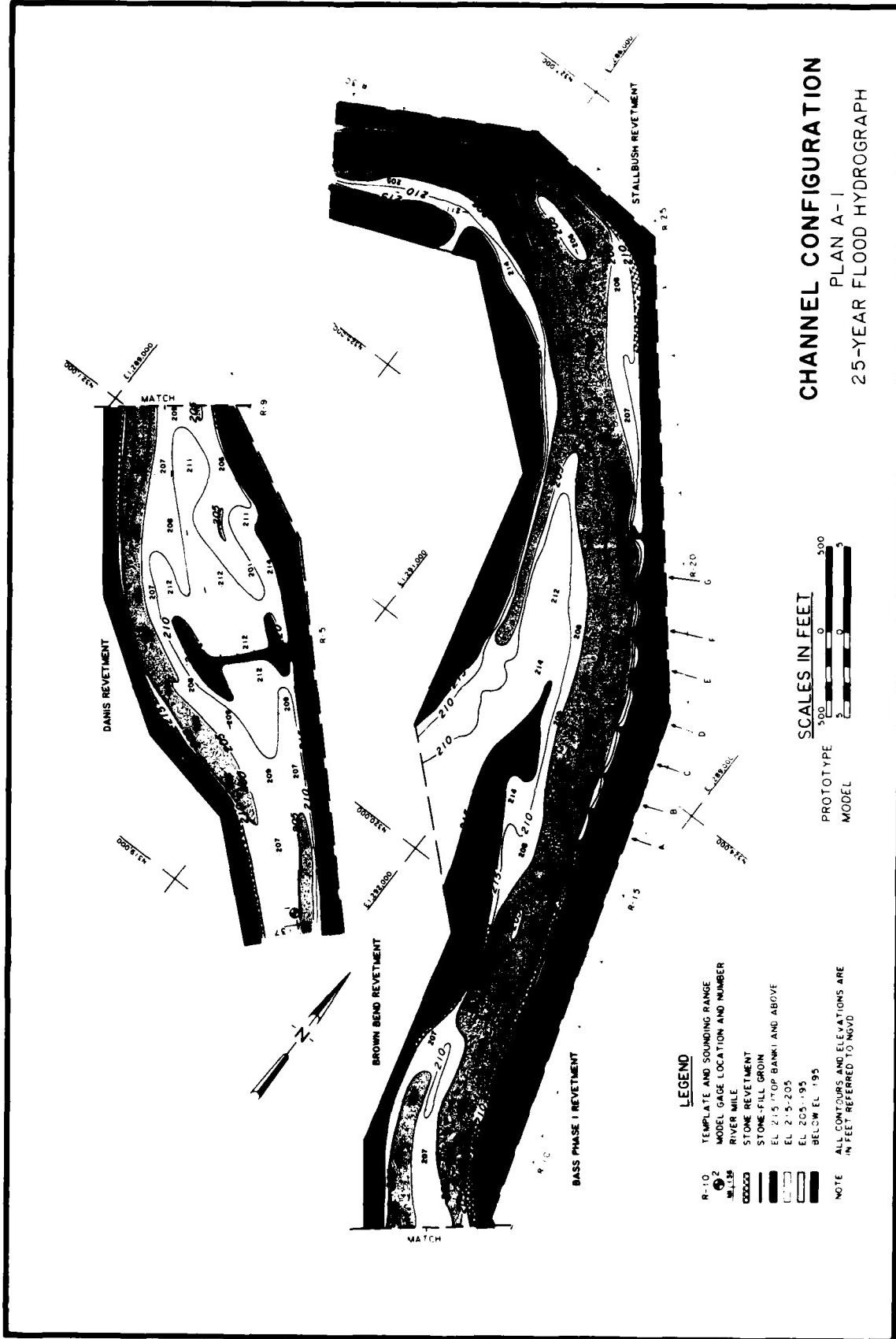
SCALES IN FEET

PROTOTYPE	200	200
MODEL	5	5

LEGEND

- R 100 TEMP. GAGE AND SOUNDING RANGE
- MODEL GAGE LOCATION AND NUMBER
- RIVER MILE
- STONE REVETMENT
- STONE FULL GROIN
- STATION POINTS AND ELEV.
- E. 100' = 2.00'
- E. 100' = 95'
- REF. AT E. 95'
- NOTE: ALL STATION AND ELEVATIONS ARE REFERRED TO NAVFAC

PLATE 14



FEND

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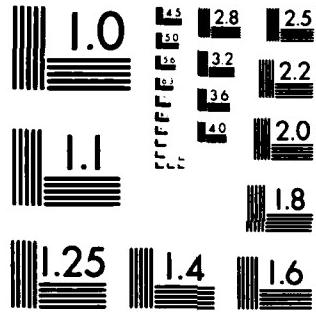


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Errata Sheet

No. 1

BANK PROTECTION, BASS LOCATION

WILLAMETTE RIVER, OREGON

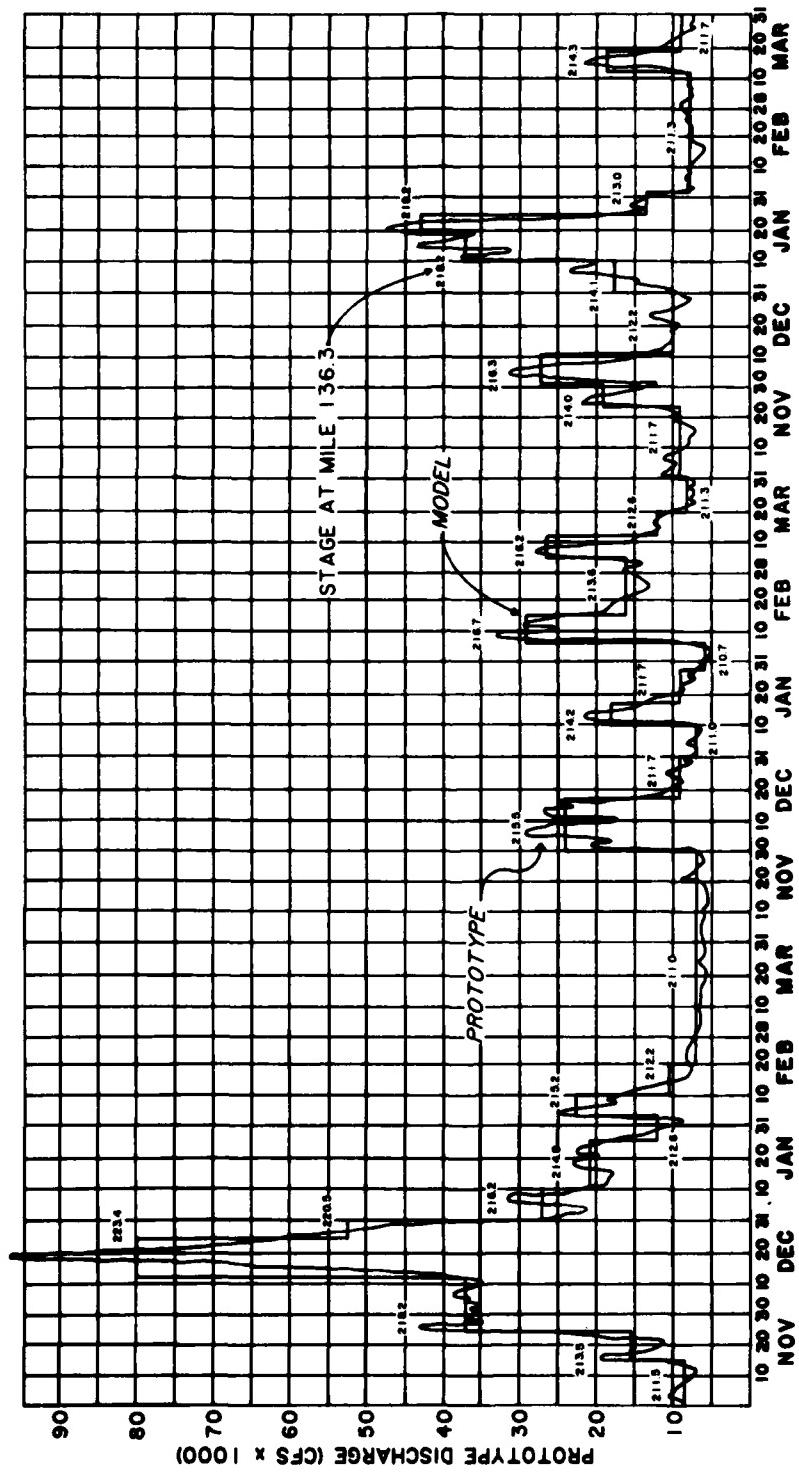
Hydraulic Model Investigation

Technical Report HL-87-7

May 1987

Delete Plate 7. Change Plate 6 to Plate 7. Insert enclosed new Plate 6.

PLATE 6



25-YEAR-FREQUENCY HIGH-WATER MONTHS HYDROGRAPH

NOTE: NUMBERS INDICATE STAGE ELEVATION IN FEET NGVD

